CERAMIC RESONATORS
for Timing Control

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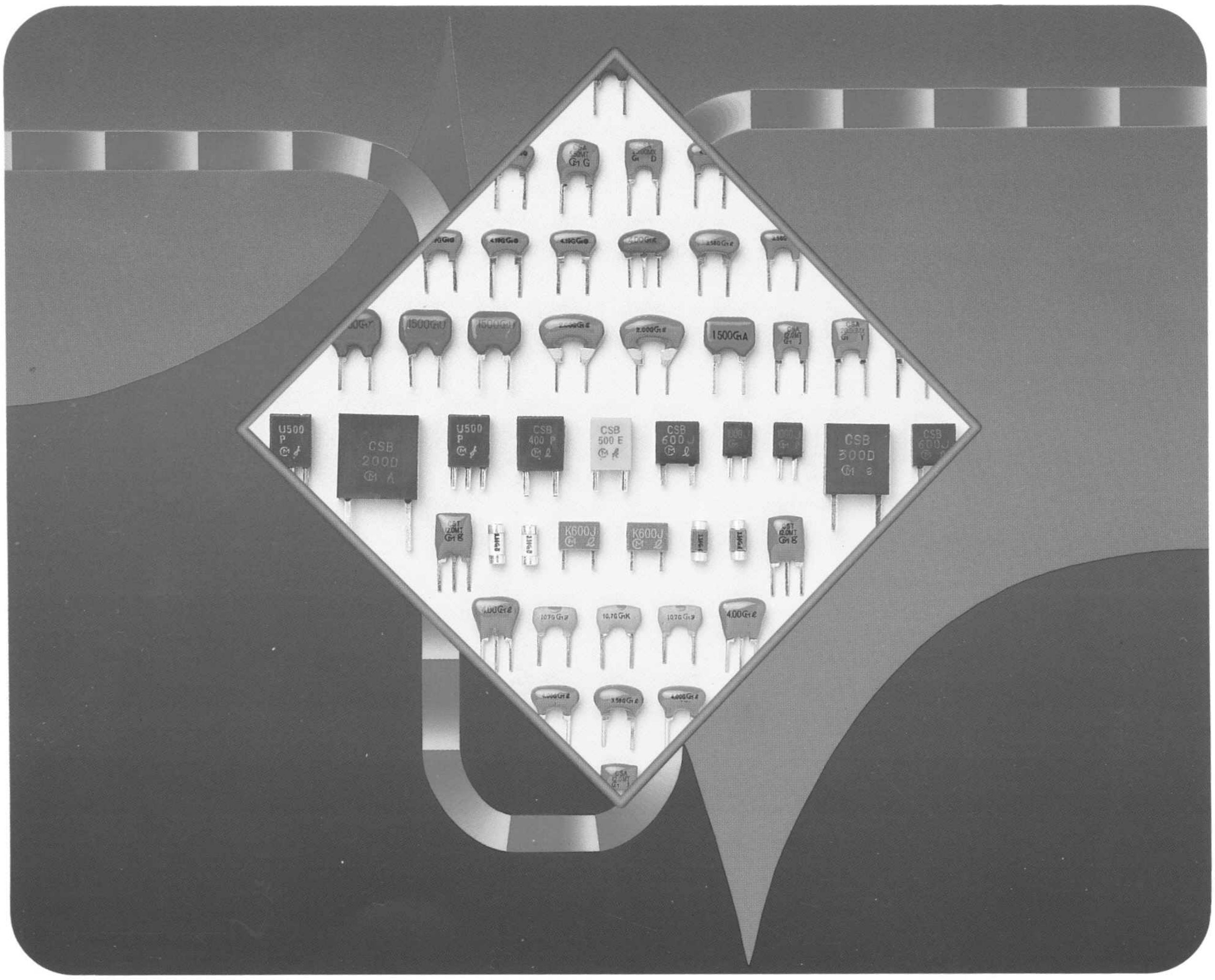

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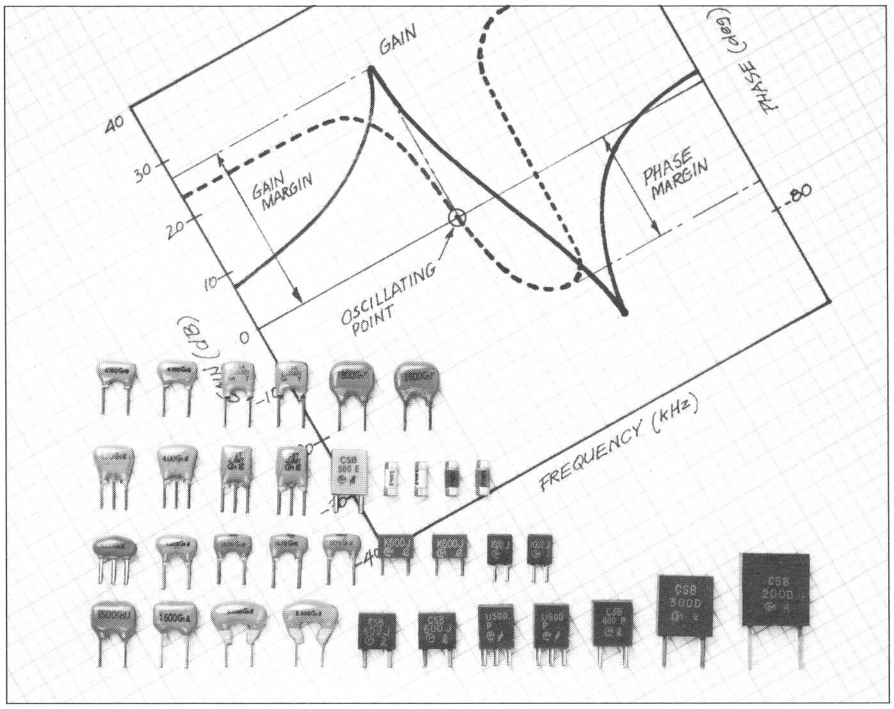
Murata Erie ceramic resonators provide a very viable alternative to expensive and fragile quartz crystals in many frequency control applications. They are currently being designed into many circuits, including computer clock generators, telephone tone generators, VCO's, etc. where size, cost and reliability are of primary concern. With a wide selection of frequencies and dimensions, a ceramic resonator can meet the specific requirements of almost any system.



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INTRODUCTION

Ceramic resonators utilize the mechanical resonance of piezoelectric ceramics. Long years of experience in the design and mass production of piezoelectric ceramic filters have enabled Murata Erie to develop and produce economical and highly reliable ceramic resonators as a stabilization component for oscillating circuits.

Advances in IC technology have made it possible to control various devices with a single LSI. Since their cost has been greatly reduced by expanded use in industrial equipment, as well as consumer electronics, it can be expected that the field of application will be expanded more in the future.

Resonators designed to provide a clock source for single chip microcomputers provide high stability and small size at substantial cost savings. Ceramic resonators currently find wide application in TV's, VCR's, automotive electronic devices, computers, telephones, copiers, cameras, voice synthesizers, communications equipment, remote controls, sewing machines, and toys.

This manual describes the theory and the application of ceramic resonators and is designed to help you use them effectively.

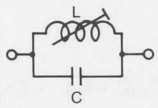
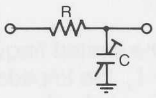
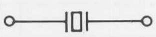
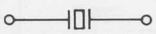
GENERAL CHARACTERISTICS

As a resonating device, quartz crystals are well-known. RC circuits and LC circuits are also well-known and often used to produce electrical resonance for oscillating circuits. Ceramic resonator technology is not as familiar to the design engineer. Following are the basic characteristics of the ceramic resonator:

- High Stability of Oscillation Frequency
  Oscillation frequency stability is between that of crystal resonators and LC or RC controlled oscillating circuits. The temperature coefficient for crystal resonators is 10^{-6} /°C maximum and approximately 10^{-3}/°C to 10^{-4}/°C for LC or RC oscillation circuits. Compared with these, the ceramic resonator has a TC of 10^{-5}/°C from −20°C to +80°C.
- Small Size and Light Weight
  The ceramic resonator is half the size of comparable devices.
- Low price, Non-adjustable
  Ceramic resonators are mass produced resulting in low cost, high stability and reliability.

Unlike RC or LC circuits, ceramic resonators utilize mechanical resonance. This means the resonator is not basically effected by external circuits or by fluctuations of the supply voltage. Highly stable oscillation circuits can therefore be made without the need for adjustment. Fig. 3-1 briefly describes the characteristics of various oscillator frequency control elements.

CHARACTERISTICS OF VARIOUS OSCILLATOR FREQUENCY CONTROL ELEMENTS—Fig. 3-1

Name	Symbol	Price	Size	Adjustment	Oscillation Frequency Initial Tolerance	Long-term Stability
LC		Inexpensive	Big	Required	±2.0%	Fair
RC		Inexpensive	Small	Required	±2.0%	Fair
Crystal Resonator		Expensive	Big	Not Required	±0.001%	Excellent
Ceramic Resonator		Inexpensive	Small	Not required	±0.5%	Excellent

OSCILLATION MODE CHARACTERISTICS OF CERAMIC RESONATORS

The oscillation mode of a ceramic resonator varies with its resonant frequency. Fig. 3-2 shows this relationship.

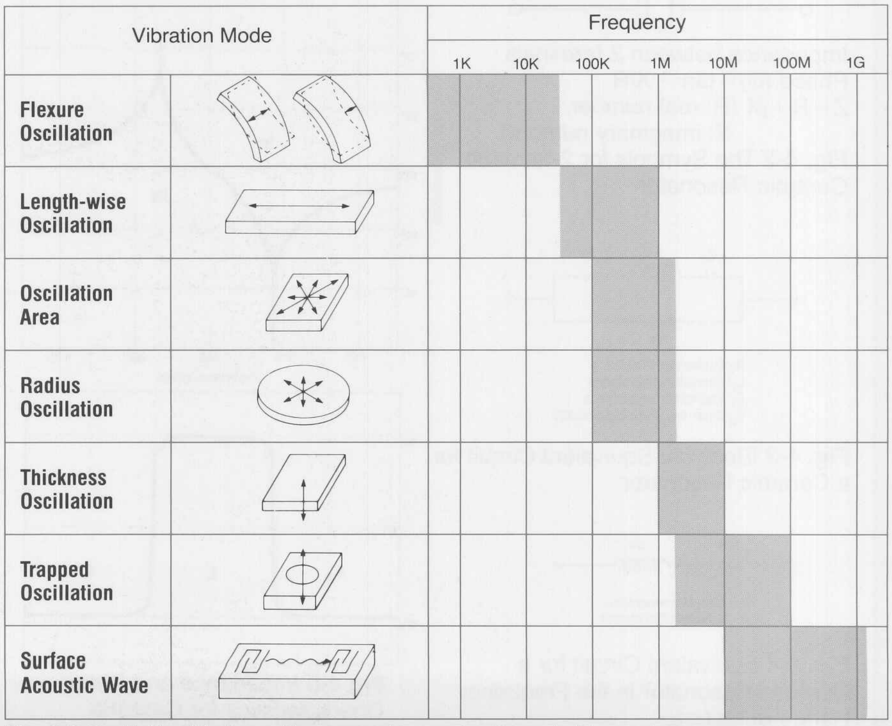


Fig. 3-2 Oscillation Mode vs. Frequency Range for Ceramic Resonators
Note: Arrow signifies the directions of the vibrations.

PRINCIPLES OF OPERATION FOR CERAMIC RESONATORS

Equivalent Circuit Constants

Fig. 4-2 shows the symbol for a ceramic resonator. The impedance and phase characteristics measured between the terminals are shown in Fig. 4-3. This figure illustrates that the resonator becomes inductive in the frequency range between the frequency f_r (resonant frequency), which provides the minimum impedance, and the frequency f_a (anti-resonant frequency), which provides the maximum impedance. It becomes capacitive in other frequency ranges. This means that the mechanical oscillation of a two-terminal resonator can be replaced with an equivalent circuit consisting of a combination of series and parallel resonant circuits with an inductor L, a capacitor C, and a resistor R. In the vicinity of the resonant frequency, the equivalent circuit can be expressed as shown in Fig. 4-4.

The f_r and f_a frequencies are determined by the piezoelectric ceramic material and its physical parameters. The equivalent circuit constants can be determined from the following formulas:

$$f_r = 1/2\pi\sqrt{L_1C_1}$$

$$f_a = 1/2\pi\sqrt{L_1C_1C_0/(C_1+C_0)} \quad = F_r\sqrt{1+C_1/C_0}$$

$$Q_m = 1/2\pi F_r C_1 R_1$$

(Q_m: Mechanical Q)

Considering the limited frequency range of $f_r \leq f \leq f_a$, the impedance is given as $Z = R_e + jwL_e$ ($L_e \leq = 0$) as shown in Fig. 4-5. The ceramic resonator should operate as an inductor L_e(H) having the loss $R_e(\Omega)$.

Fig. 4-1 shows comparisons for equivalent circuit constants between a ceramic resonator and a quartz crystal resonator. Note there is a large difference in capacitance and Q_m which results in the difference of oscillating conditions when actually operated. The table in the appendix shows the standard values of equivalent circuit constants for each type of ceramic resonator.

Higher harmonics for other modes of oscillation exist other than the desired oscillation mode. These other oscillation modes exist because the ceramic resonator uses mechanical resonance. Fig. 4-6 shows these characteristics.

	Ceramic Resonator				Crystal			
Frequency	455KHz	2.50MHz	4.00MHz	8.00MHz	453.5KHz	2.457MHz	4.00MHz	8.00MHz
L_1 (μH)	8.8×10^3	1.0×10^3	385	72	8.6×10^3	7.2×10^3	2.1×10^3	1.4×10^4
C_1 (pF)	14.5	4.2	4.4	5.9	0.015	0.005	0.007	0.027
C_0 (pF)	256.3	33.3	36.3	39.8	5.15	2.39	2.39	5.57
R_1 (Ω)	9.0	17.6	8.7	4.8	1060	37.0	22.1	8.0
Q_m	2734	912	1134	731	23000	298869	240986	88677
$\triangle$F (KHz)	12	147	228	555	0.6	3	6	19

Fig. 4-1 Comparisons of equivalent Circuit Constants for Ceramic and Crystal Resonators

Impedance between 2 terminals
Phase (ϕ) = $\tan^{-1}$ X/R
Z = R + jX (R: real number,
X: imaginary number)

Fig. 4-2 The Symbols for 2-terminal Ceramic Resonator

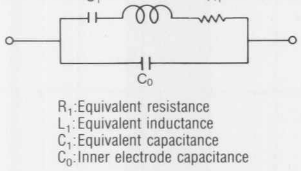


Fig. 4-3 Electrical Equivalent Circuit for a Ceramic Resonator

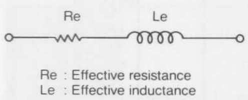


Fig. 4-4 Equivalent Circuit for a Ceramic Resonator in the Frequency Range of $f_r \leq f \leq f_a$

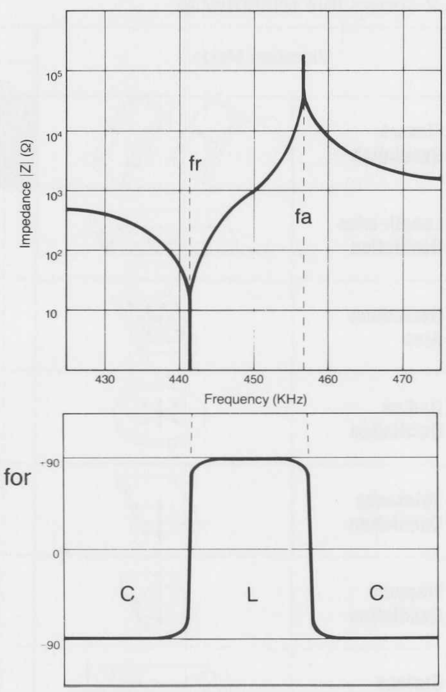


Fig 4-5 Impedance and Phase Characteristics for Ceramic Resonators

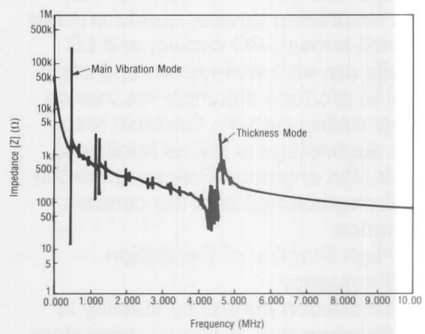


Fig. 4-6 Spurious Characteristics for a Typical Ceramic Resonator (CSB455E)

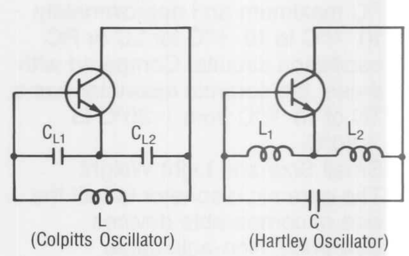


Fig. 4-7 Basic Configuration for an LC Oscillation Circuit

Basic Oscillating Circuits

Generally, the oscillating circuits can be grouped into the following three types:

1. Positive feedback
2. Negative resistance element
3. Delay of transfer time or phase

In the case of ceramic resonators, quartz crystal resonators, and LC oscillators, positive feedback is the circuit of choice.

Among the positive feedback oscillation circuits using LC, the tuning type anti-coupling oscillation circuit, by Colpitts and Hartley, are typically used. See Fig. 4-7.

In Fig. 4-7, a transistor, which is the most basic amplifier, is used.

The oscillation frequencies are approximately the same as the resonance frequency of the circuit consisting of L, C_{L1}, and C_{L2} in the Colpitts circuit or consisting of L_1, L_2, and C in the Hartley circuit. These frequencies can be represented by the following formulas.

Colpitts Circuit

$$f_{osc} = \frac{1}{2\pi\sqrt{L \cdot [(C_{L1} \cdot C_{L2})/(C_{L1} + C_{L2})]}}$$

Hartley Circuit

$$f_{osc} = \frac{1}{2\pi\sqrt{C(L_1 + L_2)}}$$

In a ceramic resonator oscillator, the inductor is replaced by a ceramic resonator, taking advantage of the fact that the resonator becomes inductive between resonant and anti-resonant frequencies. The most commonly used circuit is the Colpitts circuit.

The operating principle of these oscillation circuits can be seen in Fig. 5-1. Oscillation occurs when the following conditions are satisfied.

Loop gain: $G = \alpha \cdot \beta \geq 1$

Phase amount $\phi_T = \phi_1 + \phi_2 = 360° \cdot n$ (n = 1,2,....)

In a Colpitts circuit, an inversion of $\phi_1 = 180°$ is used, and it is inverted more than $\phi_2 = 180°$ with L and C in the feedback circuit. The operation with a ceramic resonator can be considered as the same.

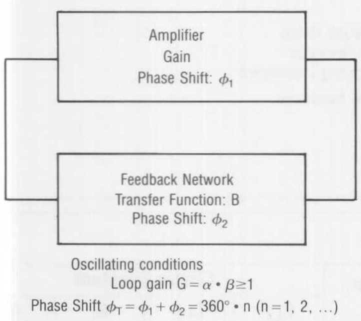


Fig. 5-1 Principle of Oscillation

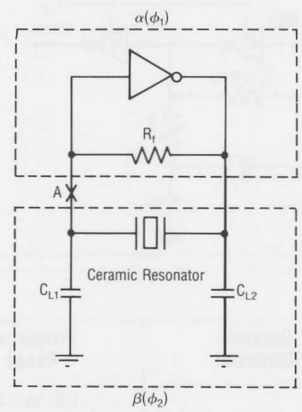


Fig. 5-2 Basic Oscillation Circuit with Inverters

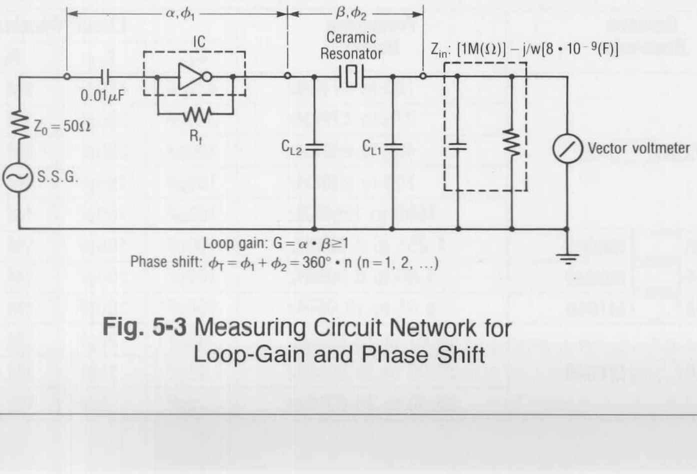


Fig. 5-3 Measuring Circuit Network for Loop-Gain and Phase Shift

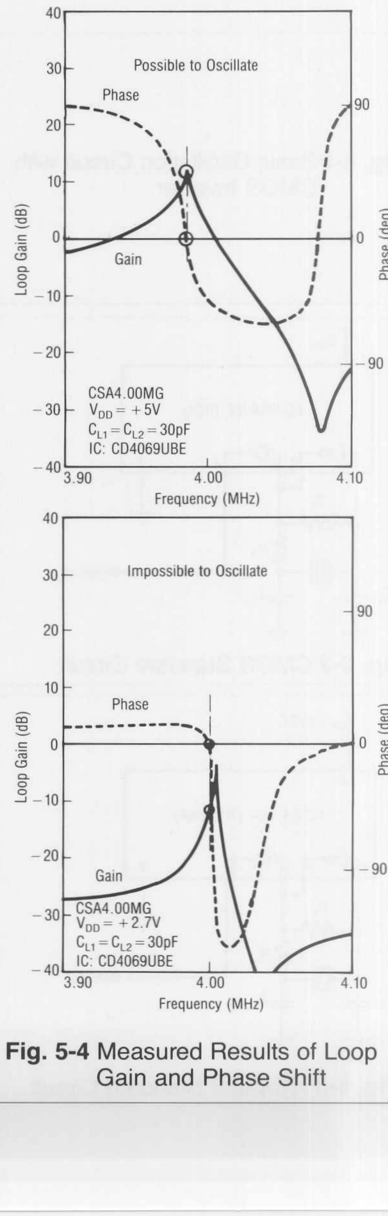


Fig. 5-4 Measured Results of Loop Gain and Phase Shift

APPLICATIONS

Typical Oscillation Circuit

The most common oscillator circuit for a ceramic resonator is a Colpitts circuit. The design of the circuit varies with the application and the IC to be used, etc. Although the basic configuration of the circuit is the same as that of a crystal controlled oscillator, the difference in mechanical Q results from a difference in circuit constants. Some typical examples follow.

Design Considerations

It is becoming more common to configure the oscillation circuit with a digital IC, using an inverter gate. Fig. 6-1 shows the configuration of a basic oscillation circuit with a CMOS inverter.

INV.1 operates as an inverting amplifier for the oscillating circuit. INV.2 is used as a waveform shaper and also acts as a buffer for the output.

The feedback resistance R_f provides negative feedback around the inverter so that oscillation will start when power is applied.

If the value of R_f is too large and the insulation resistance of the input inverter is accidentally decreased, then oscillation will stop due to the loss of loop gain. Also, if R_f is too great, noise from other circuits can be introduced into the oscillation circuit. Obviously, if R_f is too small, loop gain will be decreased. An R_f of 1MΩ is generally used with a ceramic resonator.

Dumping resistor R_d has the following function although it is sometimes omitted. It makes the coupling between the inverter and the feedback circuit loose; thereby, decreasing the load on the output side of the inverter. In addition, the phase of the feedback circuit is stabilized. It also provides a means of reducing the gain in the high frequency area, thus preventing the possibility of spurious oscillation.

Loading Capacitance

Load capacitance C_{L1} and C_{L2} provide a phase lag of 180°. These values should be properly selected depending on the application, the IC used and the frequency. If C_{L1} and C_{L2} are lower values than necessary, the loop gain at high frequencies is increased, which in turn increases the probability of spurious oscillation. This is particularly likely around 4-5MHz where the thickness vibration mode lies.

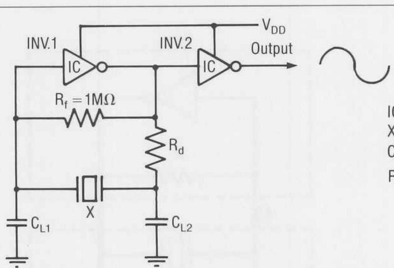


Fig. 6-1 Basic Oscillation Circuit with CMOS Inverter

IC : CD4069UBE (MOS)
X : Ceramic Resonator
C_{L1}, C_{L2}: Loading Capacitance
R_d: Damping Resistance

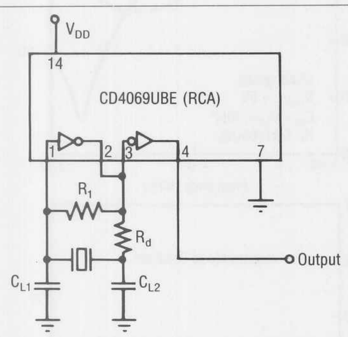


Fig. 6-2 CMOS Standard Circuit

Ceramic Resonator	Frequency Range	V_{DD}	Circuit Constant C_{L1}	C_{L2}	R_f	R_d
CSB Series	190 to 249KHz	+5V	330pF	470pF	1M	0
	250 to 374KHz		220pF	470pF	1M	0
	375 to 429KHz		120pF	470pF	1M	0
	430 to 699KHz		100pF	100pF	1M	0
	700 to 1250KHz		100pF	100pF	1M	5.6K
CSA ☐ MK	1.251 to 1.80MHz	+5V	30pF	30pF	1M	0
CSA ☐ MG	1.80 to 6.00MHz	+5V	30pF	30pF	1M	0
CSA ☐ MT	6.01 to 13.0MHz	+12V	30pF	30pF	1M	0

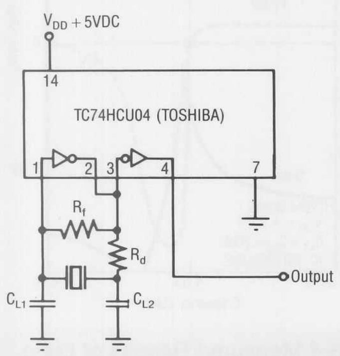


Fig. 6-3 HC-MOS Standard Circuit

Ceramic Resonator	Frequency Range	Circuit Constant C_{L1}	C_{L2}	R_f	R_d
CSB ☐ 40	190 to 374KHz	470pF	470pF	1M	5.6K
	375 to 429KHz	330pF	330pF	1M	5.6K
	430 to 699KHz	220pF	220pF	1M	5.6K
	700 to 999KHz	150pF	150pF	1M	5.6K
	1000 to 1250KHz	100pF	100pF	1M	5.6K
CSA ☐ MK040	1.251 to 1.80MHz	100pF	100pF	1M	1.0K
CSA ☐ MG040	1.80 to 6.00MHz	100pF	100pF	1M	680
CSA ☐ MT040	6.01 to 13.0MHz	100pF	100pF	1M	220
CSA ☐ MX040	13.01 to 19.99MHz	30pF	30pF	1M	0
	20.00 to 25.99MHz	15pF	15pF	1M	0
	26.00 to 30.00MHz	5pF	5pF	1M	0

Oscillation frequency (f_{osc}) in this circuit is expressed approximately by the following equation.

$$f_{osc}=f_r\sqrt{1+(C_1/C_0+C_L)}$$

Where, f_r: Resonance frequency of the ceramic resonator.

C_1: Equivalent series capacitance of the ceramic resonator.

C_0: Equivalent parallel capacitance of the ceramic resonator.

$C_L=C_{L1}\bullet C_{L2}/C_{L1}+C_{L2}$

This clearly shows that the oscillation frequency is influenced by the loading capacitance. Caution should be taken in defining its value when a tight tolerance for oscillation frequency is required.

CMOS Inverter

A CMOS inverter can be used as the inverting amplifier; the one-stage type of the 4069 CMOS group is most useful. Because of excessive gain, ring oscillation or CR oscillation is a typical problem when using the three-stage buffer type inverter, such as the 4049 group. Murata Erie employs the RCA CD4069UBE as a CMOS standard circuit, as shown in Fig. 6-2.

HC-MOS Inverter Circuit

Recently, the high speed CMOS (HC-MOS) is increasingly being used for circuits allowing high speed and low power consumption for microprocessors.

There are two types HC-MOS inverters: the un-buffered 74HCU series and the 74HC series with buffers. The 74HCU system is optimum for ceramic resonators. See Fig. 6-3.

TTL Inverter Circuit

Fig. 7-1 shows the standard circuit with an LS-TTL inverter. The value of load capacitance C_{L1} and C_{L2} should be greater than those of CMOS due to impedance matching. In addition, the feedback resistance R_f should be as small as several KΩ. Note that the bias resistance R_d is required to properly determine the DC operating point.

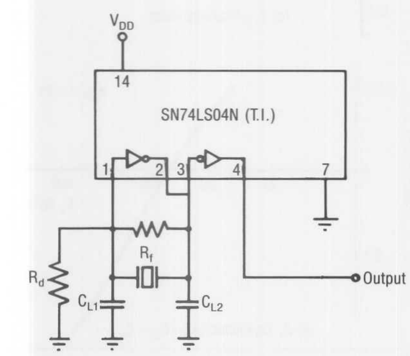


Fig. 7-1 TTL Standard Circuit

Ceramic Resonator	Frequency Range	Circuit Constant			
		C_{L1}	C_{L2}	R_f	R_d
CSA□MK011	1.251 to 1.499MHz	1500pF	2000pF	4.7KΩ	22KΩ
	1.500 to 1.999MHz	1500pF	1500pF	4.7KΩ	22KΩ
CSA□MG011	2.000 to 2.49MHz	1000pF	1000pF	4.7KΩ	22KΩ
	2.50 to 3.99MHz	1000pF	1000pF	4.7KΩ	10KΩ
	4.00 to 4.99MHz	680pF	680pF	4.7KΩ	10KΩ
	5.00 to 6.00MHz	470pF	470pF	4.7KΩ	10KΩ
CSA□MT011	6.01 to 6.99MHz	470pF	470pF	4.7KΩ	10KΩ
	7.00 to 8.99MHz	330pF	330pF	4.7KΩ	10KΩ
	9.00 to 11.99MHz	220pF	220pF	4.7KΩ	10KΩ
CSA□MX011	12.00 to 13.99MHz	220pF	220pF	2.2KΩ	22KΩ
	14.00 to 17.99MHz	150pF	150pF	2.2KΩ	22KΩ
	18.00 to 21.99MHz	100pF	100pF	2.2KΩ	22KΩ
	22.00 to 25.99MHz	68pF	68pF	4.7KΩ	22KΩ
	26.00 to 30.00MHz	47pF	47pF	4.7KΩ	22KΩ

CHARACTERISTICS OF CERAMIC RESONATOR OSCILLATION

The following describes the general characteristics of oscillation in the basic circuit of Fig. 8-1. Contact Murata Erie for detailed characteristics of oscillation with specific kinds of IC's and LSI's.

Fig. 8-2 shows examples of actual measurements for stability of oscillation frequency. The stability against temperature change is ±0.3 to 0.5% within a range of −20°C to +80°C, although it varies slightly depending on the ceramic material. Influences of load capacitance (C_{L1}, C_{L2}) on the oscillation frequency is relatively high as can be calculated from the formula for f_{osc} (see pg. 7). The f_{osc} varies by approximately ±0.1% because of the capacitance deviation of ±0.1% in the working voltage range. The f_{osc} also varies with the characteristics of the IC.

SUPPLY VOLTAGE VARIATION CHARACTERISTICS

See Fig. 8-1 for an example of an actual measurement of stability for a given oscillation frequency.

OSCILLATION LEVEL

Fig. 8-2 shows examples of actual measurements of the oscillation level against temperature, supply voltage, and load capacitance (C_{L1}, C_{L2}). The oscillating level is required to be stable over a wide temperature range, and temperature characteristics be as flat as possible. This change is linear with supply voltage unless the IC has an internal constant voltage power source.

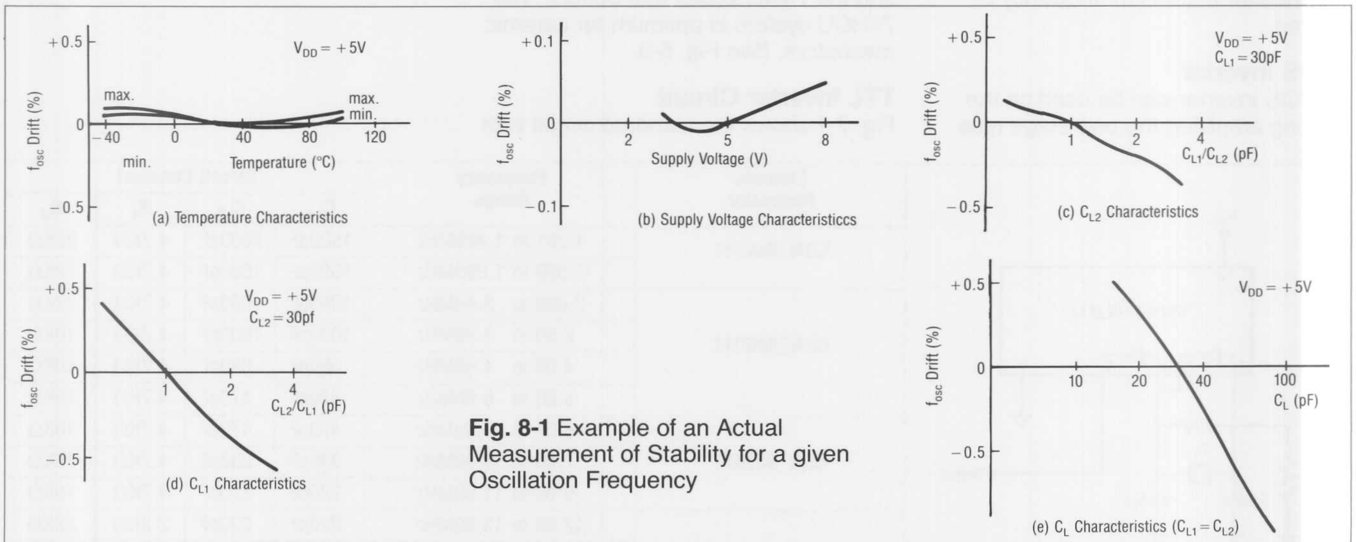


Fig. 8-1 Example of an Actual Measurement of Stability for a given Oscillation Frequency

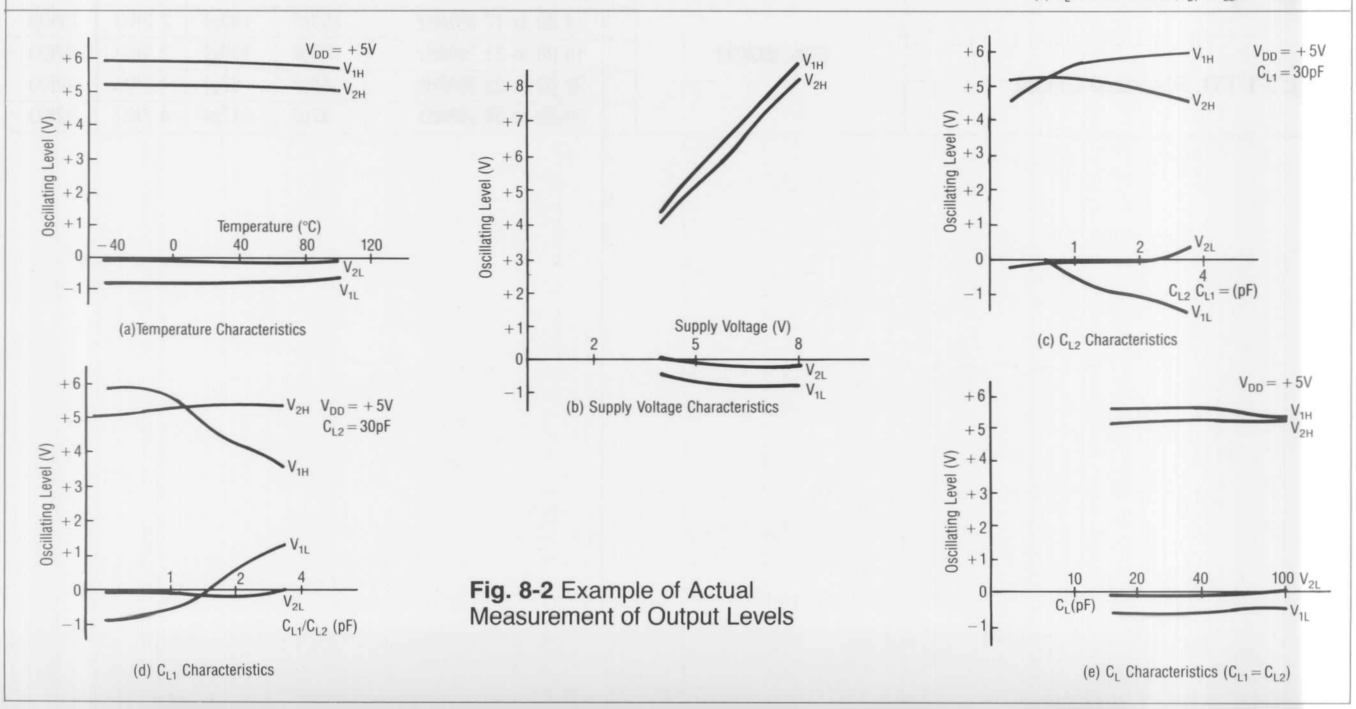


Fig. 8-2 Example of Actual Measurement of Output Levels

OSCILLATION RISE TIME

Oscillation rise time means the time when oscillation develops from a transient area to a steady area at the time the power to the IC is activated. With a ceramic resonator, it is defined as the time to reach 90% of the oscillation level under steady conditions as shown in Fig. 9-1.

Rise time is primarily a function of oscillating circuit design. Generally, smaller loading capacitance, a higher frequency ceramic resonator, and a smaller size of ceramic resonator will cause a faster rise time. The effect of load capacitance becomes more apparent as the capacitance of the resonator decreases. Fig. 9-2 shows an actual measurement of rise time against load capacitance (C_L) and supply voltage. It is noteworthy that the rise time is one or two decades faster for a ceramic resonator than for a quartz crystal.

STARTING VOLTAGE

Starting voltage means the minimum supply voltage at which an oscillating circuit can operate. Starting voltage is affected by all circuit elements. It is determined mostly by the characteristics of the IC. Fig. 9-3 shows an example of an actual measurement for the starting voltage characteristics against the loading capacitance.

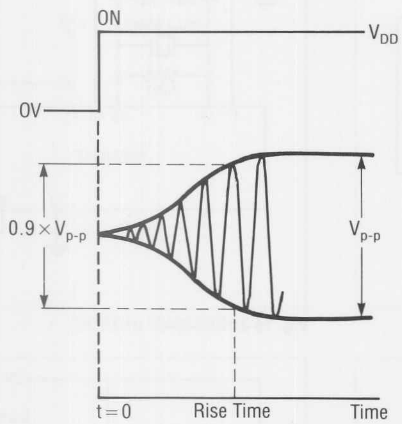
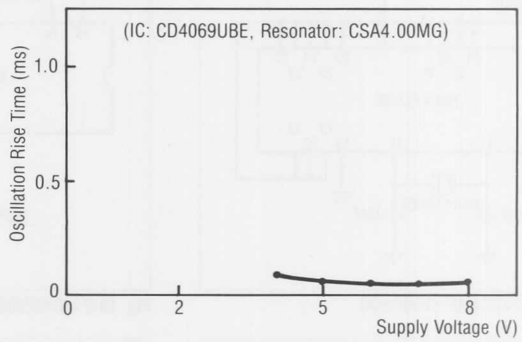
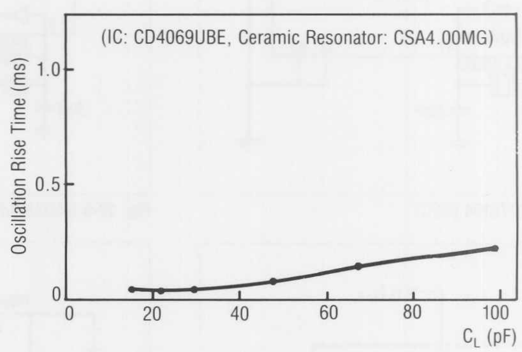


Fig. 9-1 Definition of Rise Time



(a) Supply Voltage Characteristics



(b) C_L Characteristics ($C_{L1} = C_{L2}$)

Fig. 9-2 Example of Actual Measurements for the Characteristics of Oscillation Rise Time

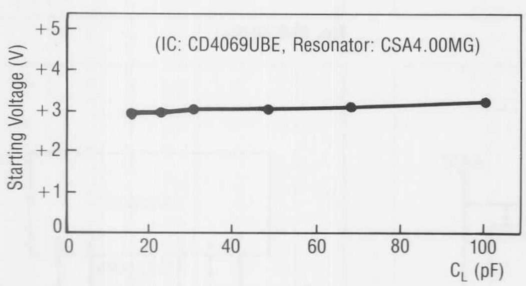


Fig. 9-3 Starting Voltage Characteristics against C_L ($C_{L1} = C_{L2}$)

Circuits for Various IC/LSI

Ceramic resonators are being used in a wide range of applications in combination with various kinds of IC's by making good use of the previously mentioned features. Following are few examples of actual applications.

Applications for Microprocessors

Ceramic resonators are optimum as a stable oscillating element for various kinds of microprocessors: 4 bit, 8 bit, and 16 bit.

As the general frequency tolerance required for the reference clock of microprocessors is ±2%-3%, standard units meet this requirement. Consult with Murata Erie or LSI manufacturers about circuit constants because they vary with frequency and the LSI circuit being used. Figs. 10-1 through 10-5 show applications with various kinds of 4 bit microprocessors, and Figs. 10-8 and 9 and 11-1 through 11-6 show applications with 8 bit microprocessors.

Remote Control IC

Remote controls have increasingly become a common feature for TV's, stereos, VCR's, and air conditioners. Fig. 11-8 shows examples of the application of ceramic resonators with remote control devices. Oscillation frequency is normally 400-500 kHz, with 455 KHz being the most popular. This 455 KHz is divided by a carrier signal generator so that approximately 38 KHz of carrier is generated.

VCO (Voltage Controlled Oscillator) Circuits

VCO circuits are used in TV's and audio equipment because the signals need to be processed in synchronization with pilot signals transmitted from broadcasting stations. Oscillation circuits, such as LC and RC were originally used; however, ceramic resonators are now used since they require no adjustment and have superior stability over the older type circuits.

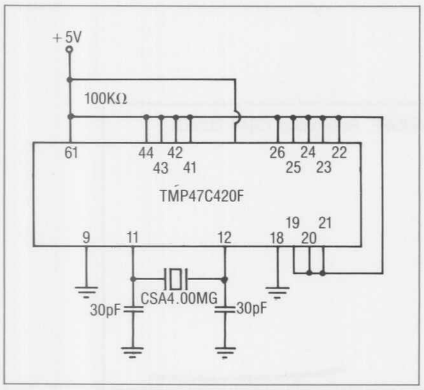


Fig. 10-1 TMP47C420F (TOSHIBA)

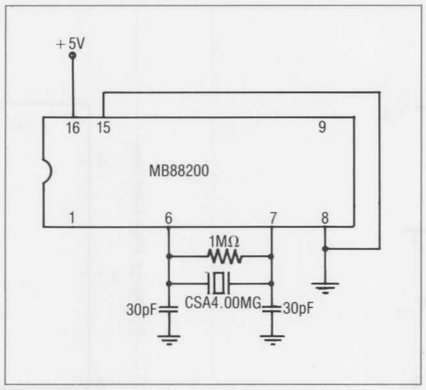


Fig. 10-2 MB88200Series (FUJITSU)

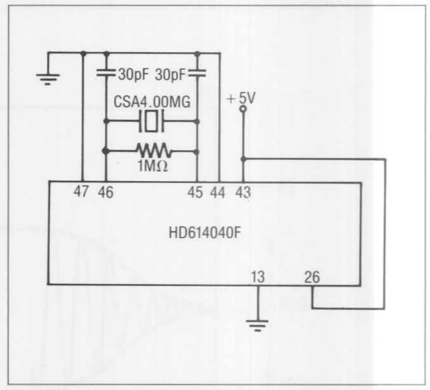


Fig. 10-3 HD614040F (HITACHI)

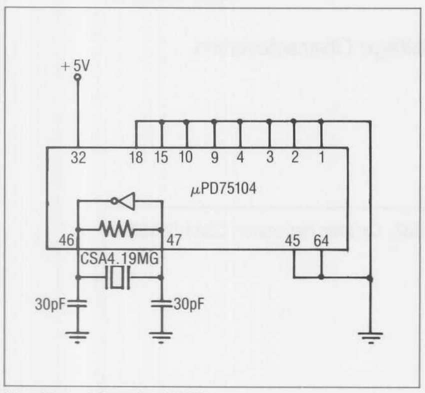


Fig. 10-4 μPD75104 (NEC)

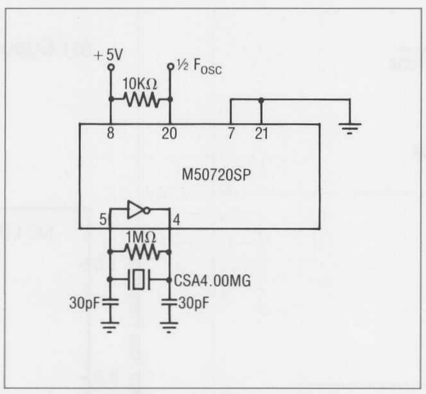


Fig. 10-5 M50720SP (MITSUBISHI)

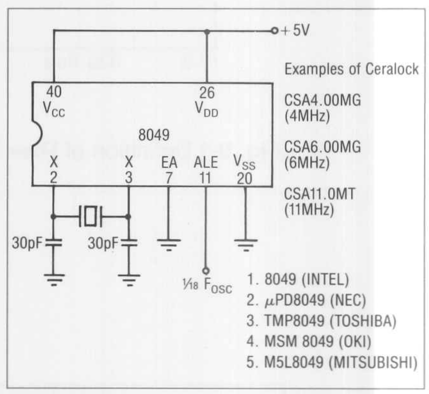


Fig. 10-6 8049s

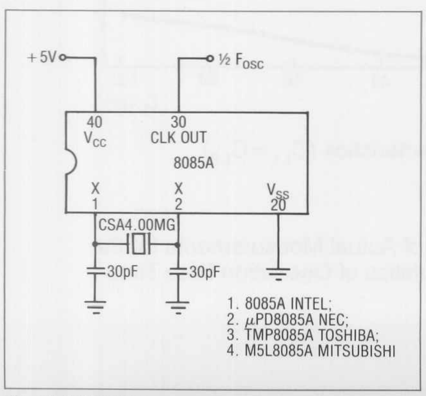


Fig. 10-7 8085As

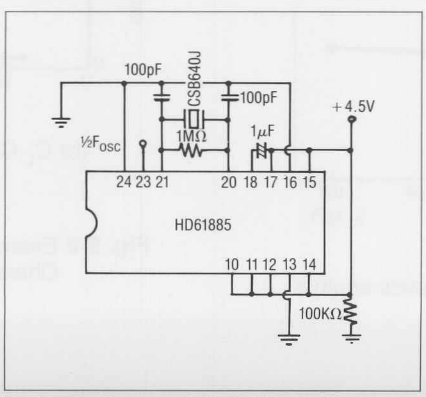


Fig. 10-8 Application with ICs for Voice Synthesis HD61885 (HITACHI)

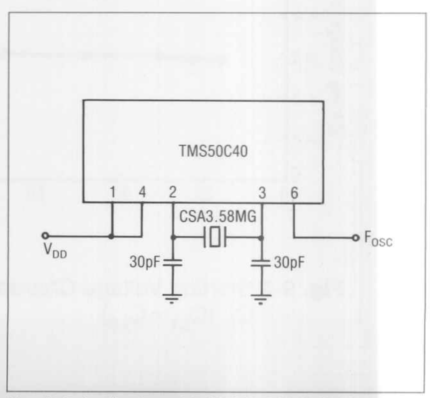


Fig. 10-9 Application with IC TMS 50C40 (T.I.)

Resonators for VCO applications are required to have a wide variable frequency range. We supply ceramic resonators with specially designed ceramic materials for VCO applications.

TV Horizontal Oscillator Circuits
Fig. 11-8 shows application example of a horizontal oscillator circuit.

Stereo Modulation Circuits
Fig. 11-9 is an FM-MPX decoder.

Telephone Dialers
Electronic telephones are becoming increasingly important as a highly advanced communication terminal. A tendency toward changing to tone dialers from pulse dialers has become apparent in order to make use of a telephone key pad for effective data transmission.

Allocated tone frequencies in columns and rows determine specific key signals by using a combination of two tones. It is mandatory to observe an overall frequency tolerance of ±1,5%, under any condition, since IC's normally have a division error of 0.1% to 0.75%. A maximum frequency tolerance of ±0.6% is allowed for the oscillator in a tone dialer.

In order to satisfy this frequency accuracy requirement, Murata Erie has designed the 3.58 MHz ceramic resonator (CSA3.58 MG300) series specifically prepared for each IC.

MISCELLANEOUS
Other than the above mentioned uses, ceramic resonators are widely used with IC's for voice synthesis and clock generation.

Figs. 10-8 and 10-9 show examples of voice synthesis. We can provide ceramic resonator application data for many IC's which are not mentioned in this manual. Please consult us for details.

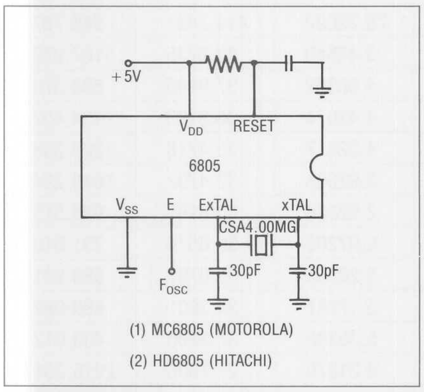


Fig. 11-1 6805s by Various Manufacturers

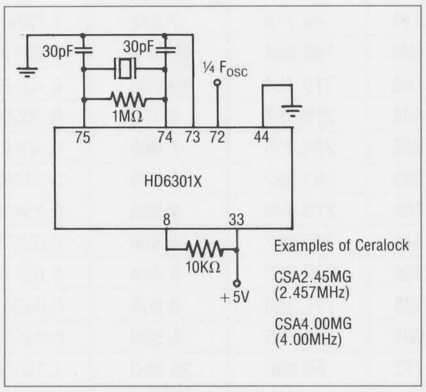


Fig. 11-2 HD6301X (HITACHI)

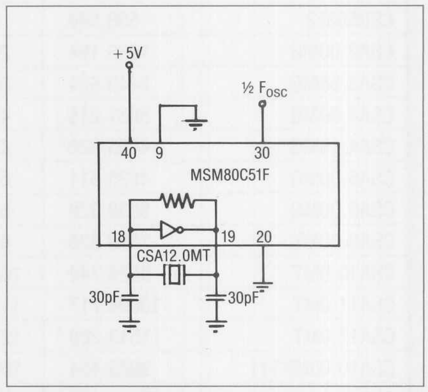


Fig. 11-3 MSM80C51F (OKI)

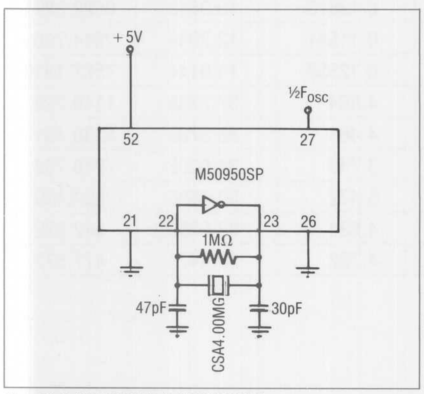


Fig. 11-4 M50950SP (MITSUBISHI)

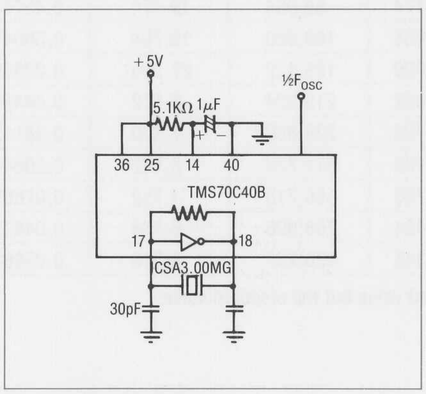


Fig. 11-5 TMS70C40B (T.I.)

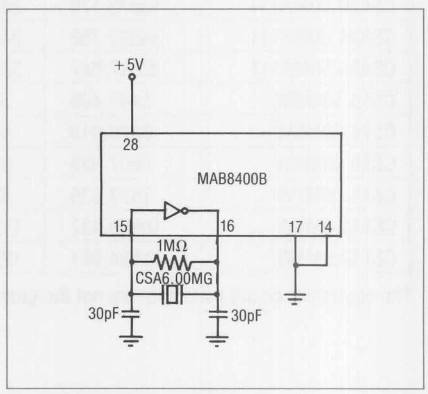


Fig. 11-6 MAB8400B (PHILIPS)

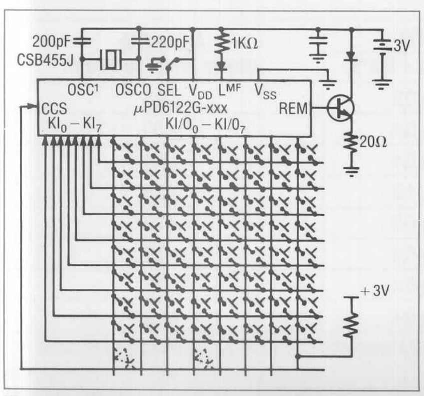


Fig. 11-7 μPD6122G (NEC)

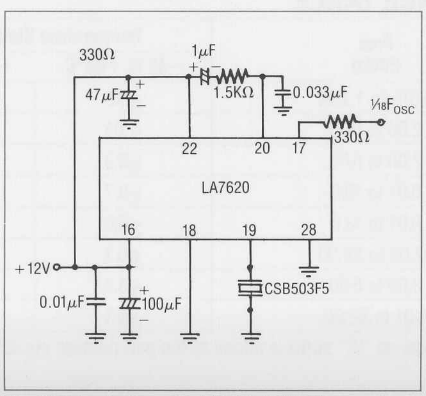


Fig. 11-8 Application with LA7620 (SANYO)

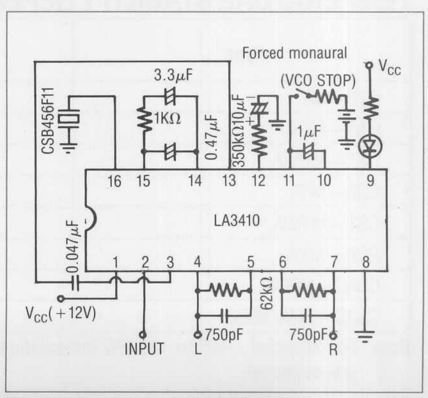


Fig. 11-9 Application with LA3410 (SANYO)

EQUIVALENT CIRCUIT CONSTANTS AND STABILITY CHARACTERISTICS

EQUIVALENT CIRCUIT CONSTANTS

Part Number	Equivalent Constant							
	F_r(KHz)	F_a(KHz)	△F(KHz)	$R_1(\Omega)$	L_1(mH)	C_1(pF)	C_0(pF)	Q_m
CSB375J	365.379	377.142	11.763	6.580	7.87150	24.10548	368.4545	2755.428
CSB440J	430.059	442.055	11.996	9.602	9.73876	14.06782	248.6922	2783.166
CSB455J	444.946	457.354	12.408	9.056	8.83390	14.50320	256.3768	2734.472
CSB480J	467.042	483.188	16.147	10.494	6.86069	16.92961	240.6704	2121.047
CSB500J	487.700	502.916	15.216	13.798	8.81911	12.08393	190.6561	2031.384
CSB560J	546.442	565.468	19.026	15.540	7.19453	11.79287	166.4471	1664.932
CSB600J	586.405	603.747	17.342	11.714	6.27444	11.78129	196.3187	2021.050
CSB640J	624.945	644.141	19.197	16.720	5.73609	11.34902	181.8710	1417.432
CSB1000J	978.840	1014.146	35.306	24.260	4.88166	5.42115	73.7989	1297.274
CSB1200J	1180.920	1224.086	43.166	44.480	4.74321	3.82996	51.4500	830.288
CSB456F11	434.789	457.804	23.014	12.460	3.96021	33.84463	311.4354	873.761
CSB500F2	505.867	550.302	44.435	8.022	1.32583	74.66130	407.1387	525.775
CSB503F2	508.546	553.319	44.773	7.572	1.28507	76.25092	414.7491	545.787
CSA2.00MG	1940.194	2046.888	106.694	20.540	1.94175	3.46649	30.6735	1167.978
CSA3.58MG	3440.604	3659.768	219.164	10.752	0.43164	4.98362	37.9146	896.370
CSA4.00MG	3861.215	4089.402	228.187	8.770	0.38504	4.42074	36.3193	1134.402
CSA4.19MG	4053.330	4288.085	234.755	7.066	0.36497	4.22817	35.4718	1328.358
CSA5.00MG	4825.611	5108.563	282.952	5.176	0.27782	3.92083	32.4792	1648.294
CSA6.00MG	5838.329	6110.758	272.429	9.998	0.25420	2.92388	30.6161	936.515
CSA8.00MT	7688.626	8244.443	555.817	4.888	0.07176	5.97208	39.8679	731.518
CSA10.0MT	9624.742	10324.266	699.522	5.464	0.05176	5.28385	35.0762	589.991
CSA11.0MT	10604.717	11376.066	771.350	6.206	0.04352	5.17987	34.3601	469.052
CSA12.0MT	11543.309	12342.664	799.355	5.990	0.03553	5.35396	37.3660	433.012
CSA10.00MX111	9983.484	10034.172	50.688	25.550	1.16302	0.21870	21.7000	2916.2017
CSA16.00MX111	15981.430	16062.057	80.627	13.728	0.53725	0.18467	18.2553	3972.9316
CSA20.00MX111	19975.178	20065.174	89.994	19.174	0.45774	0.13873	15.3613	3022.3271
CSA24.00MX111	24022.758	24131.638	108.880	19.704	0.38047	0.11541	12.7046	2944.7061
CSA30.00MX111	30017.887	30144.009	126.122	27.300	0.22389	0.12558	14.9144	1567.1316
CST3.58MGW	3445.408	3660.932	215.524	8.672	0.444295	4.804	37.2355	1149.226
CST4.00MGW	3859.919	4089.788	229.869	7.100	0.381131	4.461	36.3785	1338.401
CST6.00MGW	5807.025	6118.796	311.770	8.132	0.200447	3.749	34.0008	919.788
CST8.00MTW	7673.039	8229.756	556.718	4.752	0.078676	5.472	36.4080	831.439
CST11.0MTW	10589.437	11295.434	705.996	6.164	0.048757	4.634	33.6359	542.622
CST12.0MTW	11554.061	12380.348	826.287	5.516	0.039624	4.792	32.4478	477.577

The equivalent circuit constants are not the guaranteed value but the standard value.

TEMPERATURE STABILITY REFERENCE TABLE

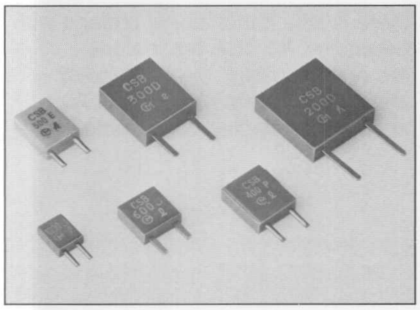
Type	Fosc (MHz)	Temperature Stability (%)		Aging (%) (Room Temp. 10 Years)
		−40 to +85°C	−40 to +125°C	
CSB—JA	0.375 to 1.250	±0.3	±0.5	±0.3
CSA—MGA	2.00 to 6.00	±.03	±0.4	±.03
CST—MGWA	2.00 to 6.00	±0.3	±0.4	±0.3
CSA—MTA	6.01 to 13.0	±0.7	±1.0	±0.5
CST—MTWA	6.01 to 13.0	±0.6	±0.9	±0.3
CSA—MXA	12.00 to 32.00	±0.3	±0.4	±0.3
CSAC—MGCA	2.00 to 6.00	±0.3	±0.4	±0.3
CSAC—MTA/MXA	6.01 to 32.00	±0.3	±0.4	±0.3

Note: For extended −40° to +125°C Temperature Range, an "A" suffix is added to the part number eq: CSB1000J becomes CSB1000JA. Applicable tolerances are as shown.

muRata ERIE

CERAMIC RESONATOR
190KHz to 1,250KHz

CSB Series



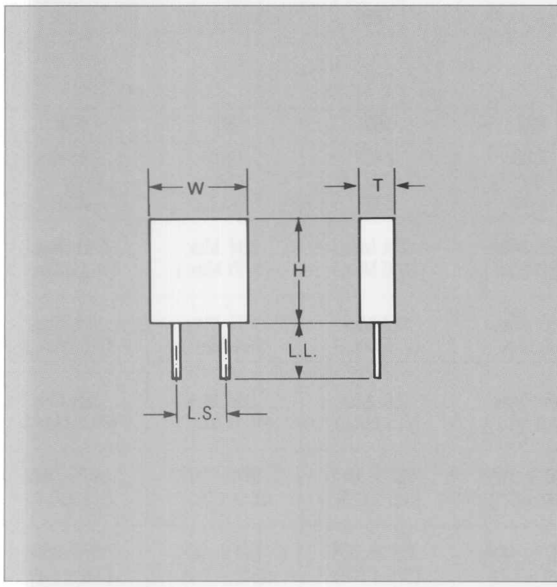
The CSB Series of ceramic resonators is designed to provide the design engineer with a rugged, relatively low frequency device in the frequency range of 190KHz to 1,250 KHz. Initial frequency tolerance is ±0.5% which compares very favorably to the nominal ±2%-3% requirements of one chip microprocessors. The CSB Series utilizes the area vibration mode of the piezoelectric ceramic element.

PART NUMBERING

CSB	1000	J	—	— —
Series	Freq. in KHz	Suffix (Denotes Construction)	For Specifying Non-Standard Frequence Tolerances (±0.3%)	Denotes any specific characteristics (Ex: 40 = HC mos type 11 = TTL type)

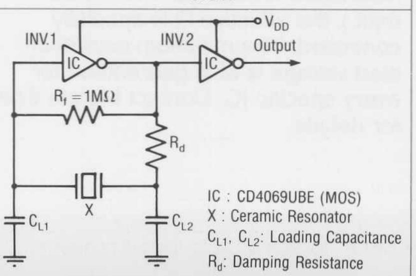
*Also available in JG-Hi Temp riton plastic

TYPICAL DIMENSIONS: in. (mm)



			Washable			
Suffix	**D**	**D**	**J**	**J**	**J**	**J**
FREQ. RANGE (KHz)	190 to 249	250 to 374	375 to 429	430 to 519	520 to 699	700 to 1,250
W	.531±0.2 (13.5±0.5)	.425±.02 (10.8±0.5)	.311±.012 (7.9±0.3)	.295±.012 (7.5±0.3)	.295±.012 (7.5±0.3)	.197±.012 (5.0±0.3)
T	.150±.02 (3.8±0.5)	.150±.02 (3.8±0.5)	.150±.012 (3.8±0.3)	.130±.012 (3.3±0.3)	.118±.012 (3.0±0.3)	.087±.008 (2.2±0.2)
H	.571±.02 (14.5±0.5)	.480±.02 (12.2±0.5)	.366±.012 (9.3±0.3)	.335±.012 (8.5±0.3)	.283±.012 (7.6±0.3)	.236±.012 (6.0±0.3)
L.S.	.398±.02 (10.1±0.5)	.303±.02 7.7±0.5)	.197±.012 (5.0±0.3)	.197±.012 (5.0±0.3)	.197±.012 (5.0±0.3)	.100±.008 (2.5±0.2)
L.L.	.354±.02 (9.0±0.5)	.264±.02 (6.7±0.5)	.157±.02 (4.0±0.5)	.138±.02 (3.5±0.5)	.138±.02 (3.5±0.5)	.138±.02 (3.5±0.5)

SPECIFICATIONS

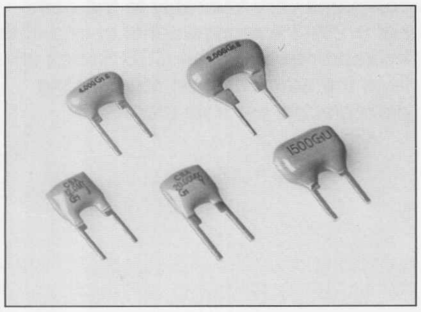
Frequency Range (KHz)	190 to 374	375 to 699	700 to 1,250
Frequency Tolerance	±1KHz	±0.5%	±0.5%
Temperature Stability (−20°C to +80°C)	±0.3%		
Aging (room temp., 10 years)	±0.3%		
Standard Test Circuit			

RESONANT IMPEDANCE

Frequency Range (KHz)	Impedance at Resonance (Ω max.)
190 to 469	20
470 to 504	30
505 to 799	40
800 to 899	60
900 to 1,099	100
1,100 to 1,250	120

CERAMIC RESONATORS
1.26MHz to 32.0MHz

CSA Series



The CSA Series of ceramic resonators cover the frequency range of 1.25MHz to 32.0MHz with an initial frequency tolerance of ±0.5%. Since the CSA Series utilizes the thickness mode of vibration of the piezoelectric element, there is little dimensional change with frequency. All CSA resonators are epoxy coated and completely washable (except MK series). Tape and reel packaging is available.

PART NUMBERING SYSTEM

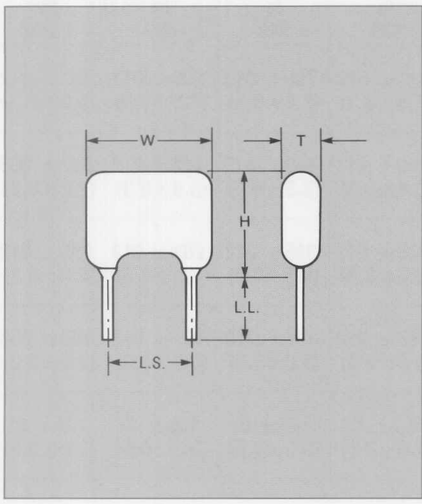
CSA 3.58 MG 1 00

- **Series** (CSA)
- **3 or 4 digits** Freq. in MHz (3.58)
- **Type** (MG)
- **Tolerance** (1)
  0 = ±0.5%
  1 = ±0.3%
  8 = ±1.0%
- **Denotes any specific characteristics** (00)

RESONANT IMPEDANCE

Type	Frequency Range (MHz)	Impedance at Resonance (Ω max)
MK	1.26 to 1.499	150
	1.500 to 1.799	100
MG	1.80 to 2.99	80
	3.00 to 3.49	50
	3.50 to 6.00	30
MT	6.01 to 6.99	30
	7.00 to 13.00	25
MX	13.00 to 32.00	40

DIMENSIONS: in. (mm)

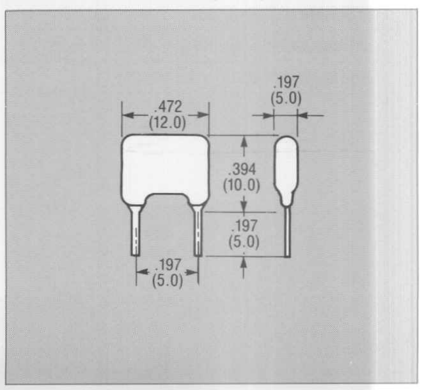


Suffix	MK	MG	MG	MT	MX
Frequency Range (MHz)	1.26 to 1.79	1.80 to 2.44	2.45 to 6.00	6.01 to 13.0	13.0 to 32.0
W	.394 Max. (10.0 Max.)	.472 Max. (12.0 Max.)	.394 Max. (10.0 Max.)	.394 Max. (10.0 Max.)	.394 Max. (10.0 Max.)
T	.197 Max. (5.0 Max.)	.197 Max. (5.0 Max.)	.197 Max. (5.0 Max.)	.197 Max. (5.0 Max.)	.197 Max. (5.0 Max.)
H	.394 Max (10.0 Max.)	.394 Max (10.0 Max.)	.295 Max (7.5 Max.)	.394 Max (10.0 Max.)	.394 Max (10.0 Max.)
L.S.	.192±.012 (4.88±0.3)	.197±.012 (5.0±0.3)	.197±.012 (5.0±0.3)	.197±.012 (5.0±0.3)	.197±.012 (5.0±0.3)
L.L.	.197±.004 (5.0±1.0)	.197±.004 (5.0±1.0)	.197±.004 (5.0±1.0)	.197±.004 (5.0±1.0)	.197±.004 (5.0±1.0)

FOR LOW VOLTAGE APPLICATIONS MGU SERIES 2.45MHz to 6.00MHz

Although the characteristics of the CSA□MGU are basically the same as those of the CSA□MG, (except for the resonance resistance which is 20 max.), the effective Q is specially controlled. The minimum oscillation start voltage is also guaranteed for every specific IC. Contact Murata Erie for details.

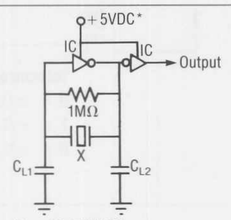
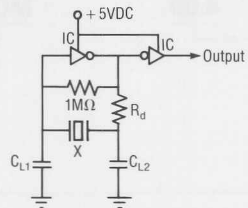
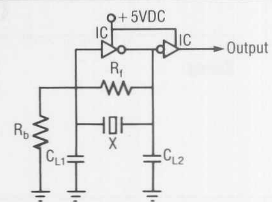
DIMENSIONS: in. (mm)



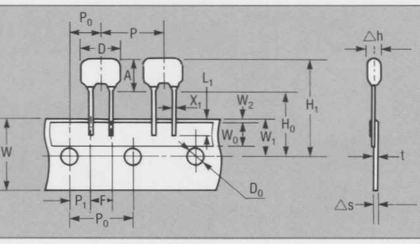
muRata ERIE

CSA Series

SPECIFICATIONS

TYPE	With MOS IC MK	MG	MT	With MOS IC MK040	MG040	MT040	MX040	With TTL IC MK011	MG011	MT011	MX011
Frequency Range (MHz)	1.26 to 1.799	1.80 to 6.00	6.01 to 13.00	1.26 to 1.799	1.80 to 6.00	6.01 to 13.00	13.01 to 32.0	1.26 to 1.799	1.80 to 6.00	6.01 to 11.99	12.00 to 30.00
Oscillation Frequency Tolerance	±0.5%			±0.5%				±0.5%			
Oscillation Frequency Temp. Stability (−20°C to +80°C)	±0.3%		±0.5%	±0.3%		±0.5%	±0.3%	±0.3%		±0.5%	±0.3%
Aging (Room Temp., 10 years)	±0.3%			±0.3%				±0.3%			
Standard Measuring Circuit	 IC: CD4069UBE V_{DD}: +5V (MT Series: +12V) X: Ceramic Resonator C_{L1}, C_{L2}: 30pF *MT Series: +12VDC			 IC: TC74HCU04 X: Ceramic Resonator C_{L1}, C_{L2}, R_d: Depends on frequency				 IC: SN74LS04 X: Ceramic Resonator C_{L1}, C_{L2}, R_f, R_b: Depends on frequency			

TAPE & REEL

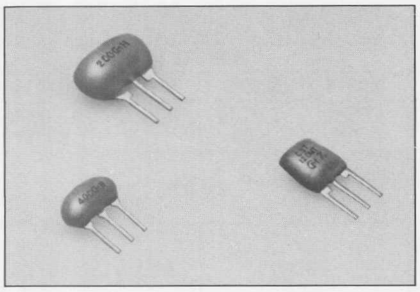


DIMENSIONS: mm

Type		TR/TF				TR01/TF01			
Item		MG		MT/MX		MG		MT/MX	
Description	Symbol	Nominal Value	Tolerance	Nominal Value	Tolerance	Nominal Value	Tolerance	Nominal Value	Tolerance
Width of Resonator	D	10.0 max.	—	10.0 max.	—	10.0 max.	—	10.0 max.	—
Height of Resonator	A	7.5 max.	—	10.0 max.	—	7.5 max	—	10.0 max.	—
Terminal Dimensions	X_1	0.5X0.3	±0.1	0.5X0.4	±0.1	0.5X0.3	±0.1	0.5X0.4	±0.1
Adhered Terminal Length	L_1	3.0 min.	—	3.0 min.	—	3.0 min.	—	3.0 min.	—
Taping Pitch	P	12.7	±0.5	12.7	±0.5	12.7	±0.5	12.7	±0.5
Guide Pitch	P_0	12.7	±0.2	12.7	±0.2	12.7	±0.2	12.7	±0.2
Hole Position to Body	P_1	3.85	±0.5	3.85	±0.5	3.85	±0.5	3.85	±0.5
Hole Position to Terminal	P_2	6.35	±0.5	6.35	±0.5	6.35	±0.5	6.35	±0.5
Terminal Spacing	F	5.0	+0.5/−0.2	5.0	+0.5/−0.2	5.0	+0.5/−0.2	5.0	+0.5/−0.2
Deviation Across Tape	$\triangle h$	0	±1.0	0	±1.0	0	±1.0	0	±1.0
Carrier Tape Width	W	18.0	±0.5	18.0	±0.5	18.0	±0.5	18.0	±0.5
Hold Down Tape Width	W_0	6.0 min.	—	6.0 min.	—	6.0 min.	—	6.0 min.	—
Position of Sprocket Hole	W_1	9.0	±0.5	9.0	±0.5	9.0	±0.5	9.0	±0.5
Hold Down Tape Width	W_2	0	+0.5/−0	0	+0.5/−0	0	+0.5/−0	0	+0.5/−0
Lead Distance Between Reference and Bottom Plane	H_0	16.0	±0.5	16.0	±0.5	18.0	±0.5	18.0	±0.5
	H_1	24.0 max.	—	26.5 max.	—	26.0 max.	—	28.5 max.	—
Diameter of Sprocket Hole	D_0	4.0D.	±0.2	4.0D.	±0.2	4.0D.	±0.2	4.0D.	±0.2
Total Tape Thickness	t	0.6	±0.2	0.6	±0.2	0.6	±0.2	0.6	±0.2

Note: The only difference between TR and TR01(TF and TF01) is the dimension of H_0.

CST Series



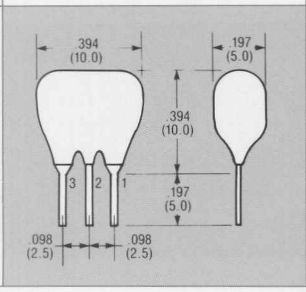
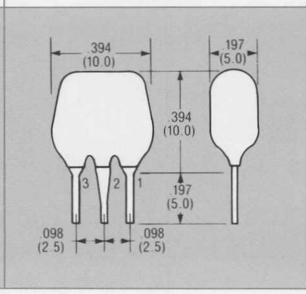
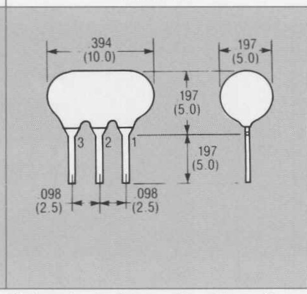
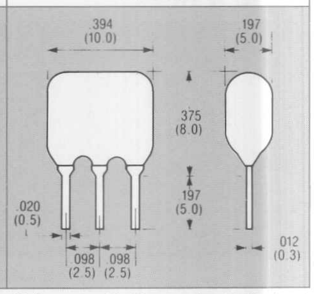
The CST Series of ceramic resonators feature a built-in load capacitance. This feature eliminates any need for external loading capacitors and reduces component count, increases reliability and reduces size. These units are offered in the frequency range from 2MHz to 13.0MHz with an initial frequency tolerance of ±0.5%.

PART NUMBERING SYSTEM

CST 4.00 MGW 1 00

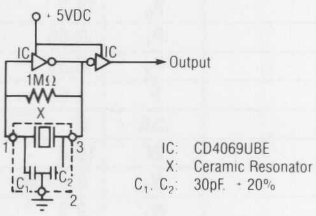
- **CST** — Series
- **4.00** — 3 or 4 digits Freq. in MHz
- **MGW** — Type
- **1** — Tolerance: 0 = ±0.5%, 1 = ±0.3%, 8 = ±1.0%
- **00** — Denotes IC

DIMENSIONS: mm

Frequency	2.00 to 2.44 MHz	6.01 to 13.0MHz	2.45 to 6.00MHz	13.01 to 25.99 MHz
Part Number	CST☐MG	CST☐MTW	CST☐MGW	CST☐MXW
Washability	Washable	Washable	Washable	Washable
Dimensions				

*Terminals have directionality. ① Input ② Ground ③ Output

SPECIFICATIONS

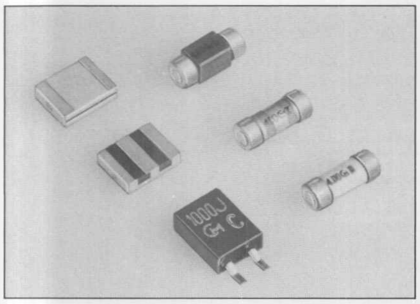
Part Number	CST☐MG	CST☐MGW	CST☐MTW	CST☐MXW
Frequency Range	2.00 to 2.44MHz	2.45 to 6.00MHz	6.01 to 13.00MHz	12.00 to 20.00MHz
Tolerance	±0.5%	±0.5%	±0.5%	±0.5%
Temperature Stability (−20°C to +80°C)	±0.3%	±0.3%	±0.4%	±0.3%
Aging (at room temperature, 10 years)	±0.3%	±0.3%	±0.3%	±0.3%
Standard Measuring Circuit				

The load capacitor of the MHz band 3-terminal CST Series is built-in. For this reason, the electrical characteristics of the CST Series are identical to those of the 2-terminal CSA Series. However, due to the characteristics of the built-in capacitor, the frequency temperature stability for the CST☐MTW type is slightly improved over that of the CSA☐MT type.

CERAMIC RESONATORS FOR SURFACE MOUNT

muRata ERiE

CSBF, CSAC-MGC/MT/MX Series

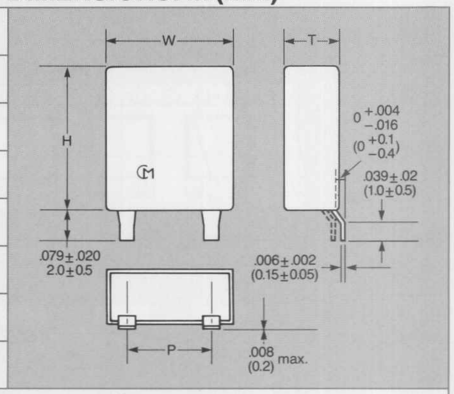


Increasing demand for size reduction and the economies realized through Surface Mount Technology, have led Murata Erie to develop the new CSBF and CSAC ceramic resonators. The CSBF is a miniaturized leaded unit offering size compatibility with most commonly available surface mount devices, while the CSAC is a true surface mountable component. Both devices, are available in tape and reel packaging compatible with most auto-placement equipment.

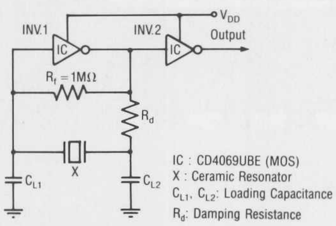
CSBF Series – 430 to 1250KHz

Frequency (kHz)	W	H	T	P
430 to 440	.295 ± .012 (7.5 ± 0.3)	.335 ± .012 (8.5 ± 0.3)	.130 ± .012 (3.3 ± 0.3)	.197 ± .008 (5 ± 0.2)
450 to 460	.295 ± .012 (7.5 ± 0.3)	.335 ± .012 (8.5 ± 0.3)	.130 ± .012 (3.3 ± 0.3)	.197 ± .008 (5 ± 0.2)
470 to 480	.295 ± .012 (7.5 ± 0.3)	.335 ± .012 (8.5 ± 0.3)	.130 ± .012 (3.3 ± 0.3)	.197 ± .008 (5 ± 0.2)
490 to 500	.295 ± .012 (7.5 ± 0.3)	.335 ± .012 (8.5 ± 0.3)	.130 ± .012 (3.3 ± 0.3)	.197 ±. 008 (5 ± 0.2)
700 to 850	.197 ± .012 (5 ± 0.3)	.256 ± .012 (6.5 ± 0.3)	.091 ± .008 (2.3 ± 0.2)	.197 ± .008 (5 ± 0.2)
910 to 1020	.197 ± .012 (5 ± 0.3)	.256 ± .012 (6.5 ± 0.3)	.091 ± .008 (2.3 ± 0.2)	.197 ± .008 (5 ± 0.2)
1200 to 1250	.197 ± .012 (5 ± 0.3)	.256 ± .012 (6.5 ± 0.3)	.091 ± .008 (2.3 ± 0.2)	.197 ± .008 (5 ± 0.2)

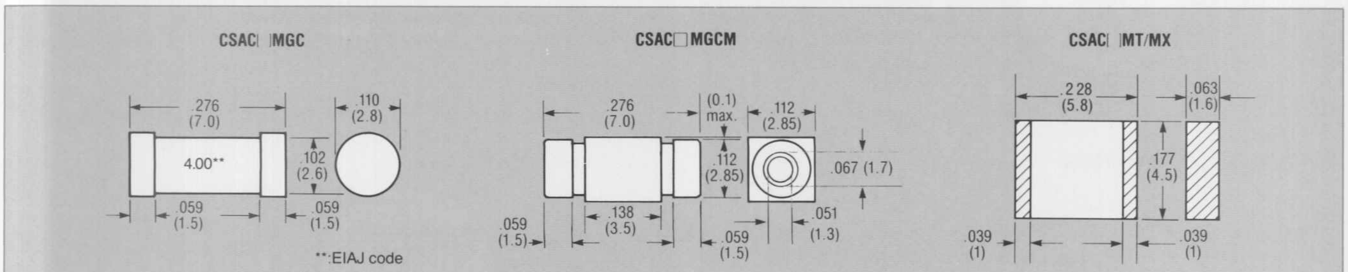
DIMENSIONS: in (mm)



SPECIFICATIONS

Frequency Tolerance	±0.5%
Temperature Stability (−20°C to +80°C)	±0.3%
Aging (room temp., 10 years)	±0.3%
Standard Test Circuit	

CSAC SERIES—2.00 to 32.00MHz
DIMENSIONS: in. (mm)



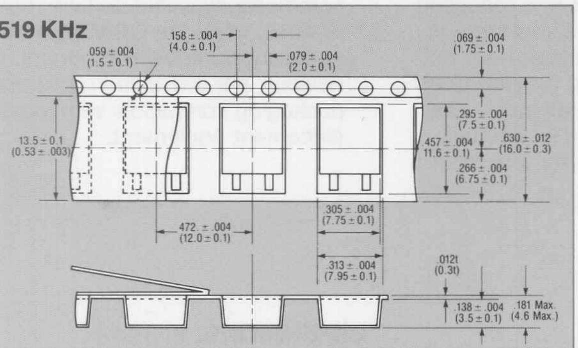
SPECIFICATIONS	CSAC☐MGC/MGCM	CSAC☐MT	CSAC☐MX
Frequency Range	2.00 to 6.00 MHz	6.01 to 13.0 MHz	13.01 to 32.00 MHz
Frequency tolerance	±0.5%	±0.5%	±0.5%
Storage Temperature Range	−40°C to +85°C		
Temperature Stability	±0.3% (−20°C to +80°C)	±0.5% (−20°C to +80°C)	±0.3% (−20°C to +80°C)
Withstand Voltage	50 VDC max.		

Note: Also available in automotive temp. grades.

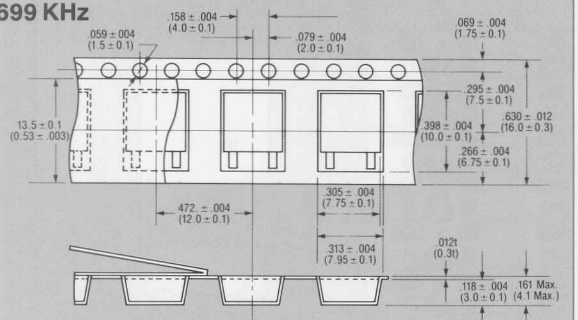
CERAMIC RESONATORS
SURFACE MOUNT
TAPE AND REEL SPECIFICATIONS CSBF, CSAC-MGC/MT/MX Series

CSBF TAPE & REEL DIMENSIONS: in. (mm) PLASTIC TAPE

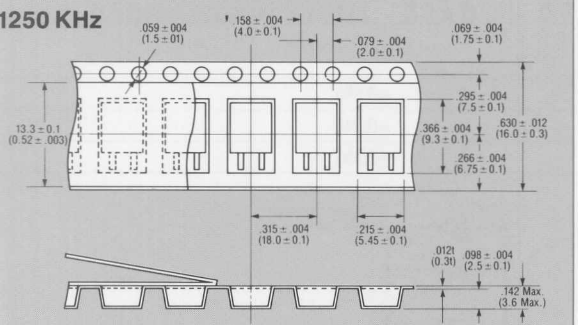
430–519 KHz



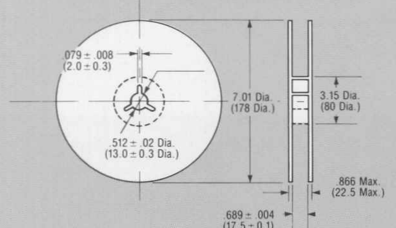
520–699 KHz



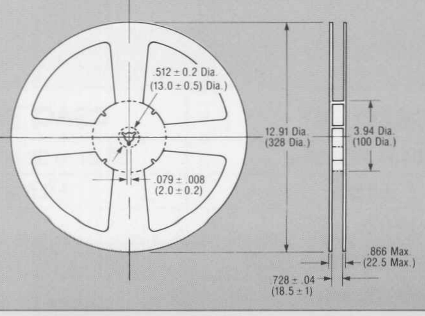
700–1250 KHz



178mm Dia. Paper Reel

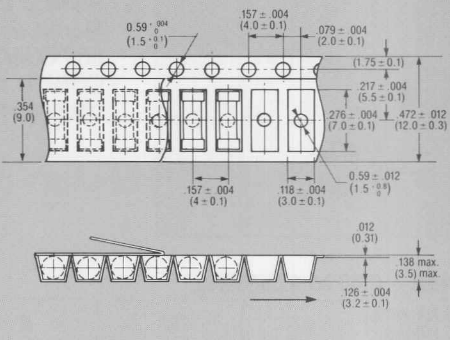


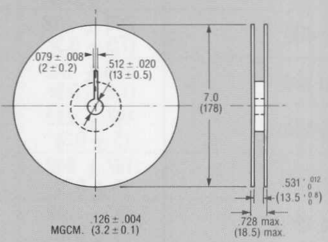
328mm Dia. Plastic Reel



CSAC MGC/M TAPE & REEL

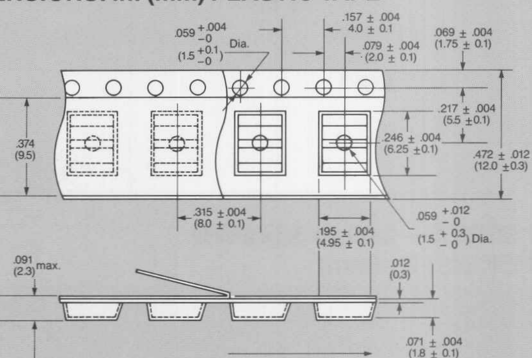
DIMENSIONS: in. (mm) PLASTIC TAPE

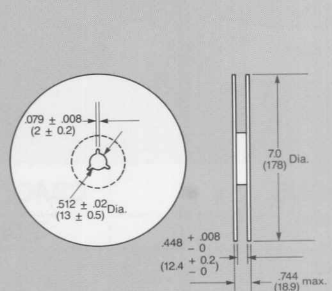




CSAC MT/MX TAPE & REEL

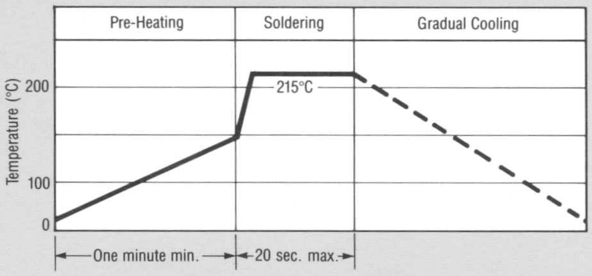
DIMENSIONS: in. (mm) PLASTIC TAPE



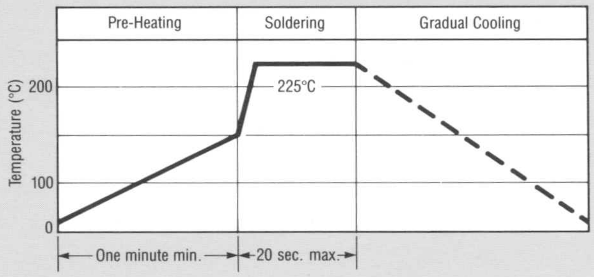


REFLOW SOLDERING TEMPERATURES

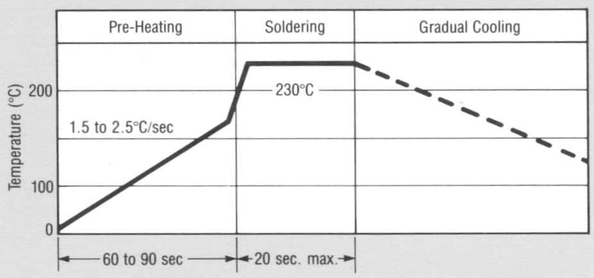
CSBF-430-699J(A) TYPE



CSBF-700-1250J(A) TYPE

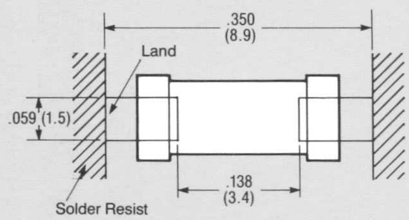


CSAC TYPE



PAD DIMENSIONS

CSAC□MGC/MGCM



CSAC□MT/MX